Effects of Fertilization on the Growth and Yield of Sweet Corn under No Tillage in Bukidnon, Philippines

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Abstract: The study was conducted to assess the impacts brought by fertilizer towards the growth and yield performance of sweet corn under no tillage operation in Bukidnon, Philippines. The study took place at the research station of IPB-UPLB, Musuan, Bukidnon, Philippines. Soil samples were taken from the site for initial characterization. Six treatments were employed; T_1- No fertilizer,T_2- Recommended rate of inorganic fertilizer (RRIF) based on soil analysis of the experimental area, T_3- 2 tons ha^{-1} Vermicompost, T_4- ½ RRIF + 1 ton ha^{-1} Vermicompost, T_5- ½ RRIF + 2 tons ha^{-1} Vermicompost and T_6- RRIF + 1 ton Vermicompost. Fertilizer treatments were incorporated in the soil to facilitate appropriate chemical reactions. Dibble planting method was employed all throughout the area. Harvesting was done at 70 days after sowing (DAS). The application of fertilizer materials in Bukidnon soil under no tillage operation has no significant effects towards the growth performance of sweet corn. The full recommended rate of inorganic fertilizer plus 1 ton Vermicompost ha^{-1} consistently gave significantly higher yield parameter values (ear diameter and ear length) than those with no fertilizer applied. Yield data was observed significantly highest in plots with full recommended rate of inorganic fertilizer and 1 ton Vermicompost ha^{-1} with a value of 49369 ears per hectare. On the other hand, soil pH was significantly affected by the application of inorganic fertilizer alone. Moreover, the application of ½ RRIF + 2 tons of Vermicompost ha^{-1} caused significant effects towards the organic matter content (%) of the soil at harvest. The use of inorganic fertilizer in combination with organic fertilizer in sweet corn production under Bukidnon soil with no tillage operation are productive means and ways to be executed. Yield response was significantly highest in those plots, thus, possible means to be implemented in Bukidnon setting following no tillage operation.

Key words: Growth, yield, sweet corn, fertilizer, no tillage, Bukidnon

1. INTRODUCTION

Most soil used to grow plants, including ornamentals, grass and vegetables, and needs the basic nutrients be replenished over time. Fertilizers boost the soil's reserves of elements essential to the healthy growth and development of plants. Although conventional and organic fertilizers both add needed nutrients to the soil, organic fertilizer differs because it is derived from natural sources as opposed to being synthetically manufactured [1].

Plants get many of the elements they need through the air. Oxygen, carbon and hydrogen are readily available. In addition, plants can create glucose and other substances through sunlight. However, basic elements cannot be created through photosynthesis, and plants must extract these elements through the soil. Even though air contains a significant amount of nitrogen, plants cannot absorb it. As a result, they must get it from the soil. Nitrogen becomes depleted in soil quickly, and the primary benefit of fertilizer is the nitrogen it provides. Plant cells also depend on potassium and phosphorous, which are rare [2]. Fertilizer contains a large amount of these elements, which ensures that plants stay healthy. Plants can generally grow without fertilizer, but they may take more time to get the elements they need to thrive. Fertilizer is essential in modern farming, and almost all farmers depend on it to keep their fields healthy and productive. Gardeners often use small amounts of fertilizer as well to ensure that their flowers and other plants look their best [3].

No tillage farming is a way of growing crops or pasture from year to year without disturbing the soil through tillage. No-till is an agricultural technique which increases the amount of water that infiltrates into the soil, the soil's retention of organic matter and its cycling of nutrients. In many agricultural regions, it can reduce or eliminate soil erosion. It increases the amount and variety of life in and on the soil, including disease-causing organisms and disease organisms, but are kept in check by a diverse and healthy soil food web. The most powerful benefit of no-tillage is improvement in soil biological fertility, making soils more resilient. Farm operations are made much more efficient, particularly improved time of sowing and better trafficability of farm operations [4,5].

The province of Bukidnon is considered to be the food basket of Mindanao, being the major producer of rice and corn in the region. Two types of climate prevail between the northern and southern sections of Bukidnon, The northern part is classified as belonging to Type III, that is, there is no pronounced rain period but relatively dry during the months of November to May. In the southern portion of the province, the climate is classified as Type IV with no dry season [6].

Sweet corn scientifically known as *Zea mays* L. *var. Saccharata* is a variety of maize with a high sugar content. Sweet corn is the result of a naturally occurring recessive mutation in the genes which control conversion of sugar to starch inside the endosperm of the corn kernel. Unlike field corn varieties, which are harvested when the kernels are dry and mature (dent stage), sweet corn must be picked when immature (milk stage) and prepared and eaten as a vegetable, rather than a grain [7].

2. MATERIALS AND METHODS

2.1 Location

The field experiment was conducted at the Research Station of IPB-UPLB (7° 51' 31.788" N and 125° 3' 40.4568" E), Central Mindanao University, Musuan, Bukidnon, Philippines.

2.2 Collection, preparation and characterization of soil samples

Surface soil samples at 0-20 cm depth were collected randomly from the experimental area following a zigzag direction prior to the land preparation. The collected soil samples were placed in cellophane bags and then brought to the Soil and Plant Analysis Laboratory (SPAL), Department of Soil Science, College of Agriculture, Central Mindanao University, Musuan, Bukidnon, Philippines wherein laboratory analyses were conducted. Prior to analysis, the collected soil samples were air-dried at room temperature for about a week, and passed through a 2-mm sieve and were stored in a clean plastic containers. Soil samples were also collected from each experimental plot after harvest of sweet corn. The chemical and physical properties of the soil were determined and analyzed at the Soil and Plant Analysis Laboratory (SPAL). The properties tested include; soil pH in 1:5 soil : water ratio [9]; organic matter content by the Walkley and Black method [8]; extractable P using the Bray 2 method [8] and exchangeable K using 1N NH_4OAc buffered at pH 7.0 using a Flame photometer [8].

2.3 Characteristics of soil in the experimental area

Table 1 shows that the soil samples collected from the experimental area has a pH value of 5.52 and is classified as strongly acidic [9]. The soil has organic matter content of 3.90% which is considered marginal [8]. For the extractable phosphorus, it has a value of 17.37 mg kg^{-1} and is classified as medium in amount [10]. On the other hand, exchangeable potassium was found high in amount because of its value 1.11 cmol kg^{-1} [10]. Hence, the fertilizer recommendation for the experimental site was 70-50-0 kg ha^{-1} of N, P_2O_5 and K_2O.

2.4 Experimental design and treatments

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with six (6) treatments and replicated three (3) times. Treatments include: T_1- no fertilizer,T_2- Recommended rate of inorganic fertilizer (RRIF) based on soil analysis of the experimental area (70 – 50 – 0 N, P_2O_5, K_2O kg ha^{-1}), T_3- 2 tons ha^{-1} Vermicompost, T_4- ½ RRIF (35 – 25 – 0 N, P_2O_5, K_2O kg ha^{-1}) + 1 ton ha^{-1} Vermicompost, T_5- ½ RRIF (35 – 25 – 0 N, P_2O_5, K_2O kg ha^{-1}) + 2 tons ha^{-1} Vermicompost and T_6- RRIF (70 – 50 – 0 N, P_2O_5, K_2O kg ha^{-1}) + 1 ton Vermicompost.

2.5 Land preparation and lay-outing

The field was left unplowed to facilitate no tillage condition. A pre-emergence herbicide was used to control emerging weeds, this was observed in all the experimental plots. The total land area used in the experiment was 463.75 m^2 (35 m x 13.25 m). It was divided into three (3) blocks and each block had a dimension of 131.25 m^2. A one meter space was provided between blocks and experimental plots as alleyways.

2.6 Fertilizer application and seeding operation

The Vermicompost was sourced out from one of the Vermi farms in Valencia City, Bukidnon, Philippines. The Vermicompost was applied in those plots assigned with organic fertilizer as treatment following the rate of two (2) tons ha^{-1}. It was carefully broadcasted within each plot before the seeding operation. While basal application of inorganic fertilizer was done in treatments assigned to inorganic fertilizer. Inorganic fertilizers were placed in a hole covered with a thin layer of soil then followed by the sowing of seeds and then covered again with soil to have a close contact between the seed and the soil, thus, would facilitate uniform germination. The chemical assay of Vermicompost used in the experiment include: pH of 6.52 and an organic matter content of 32.45 %. For the nutrient content, total nitrogen of 2.82 %, total phosphorus of 1.14 % and total potassium of 0.45 %.

Table 1. Chemical properties of soil in the experimental soil (0-20 cm)

Properties	Value	Methods
pH	5.52	Potentiometric (1:5 soil : water)
Organic Matter Content, %	3.90	Walkley-Black
Extractable Phosphorus, mg kg^{-1}	17.37	Bray P_2
Exchangeable Potassium, cmol kg^{-1}	1.11	1N NH_4OAc / Flame photometer

Since no furrows were made to serve as a guide for planting, a line was drawn using a stick served as demarcation in sowing the seeds. Dibble planting method was done on these plots. The seeds were sown at a distance of 0.25 m between hills. There were six (6) rows in every experimental plot with 5 m in length. The planting distance of 0.25 m between hills and 0.75 m between rows was then observed. One row in both sides of the plot served as the guard rows while the inner 4 rows served as the data rows from which agronomic and yield data were derived.

2.7 Care and management

Care and management immediately started right after seeding up to the harvesting period. Weed population was closely monitored to avoid possible competition of nutrients. Moreover, disease monitoring was also done. Application of pesticides was also employed due to the evident infestation of insect pests. Due to adverse climatic condition during the conduct of the experiment, irrigation was done once a week to sustain the water need of the crop. Irrigation ceased when the experimental plants were about to be harvested at 70 DAS.

2.8 Tagging of data plants and harvesting

Ten (10) sample plants were randomly selected from data rows in each experimental plot. A sheet of white paper was stapled to each data plants to serve as marker and guide during data collection. During the harvesting, the data plants were harvested first followed by the guard rows. Ears were carefully separated from its stover to avoid damage of produce. Yield data collection was then employed and other parameters.

2.9 Statistical analysis

Statistical analysis was done after tabulating the gathered data through the Statistical Tool for Agricultural Research (STAR) software. Moreover, some parameters were found significant as manifested in the F computed value, comparison of means then proceeded using Honestly Significance Difference (HSD) test as the Post hoc test undertaken [11].

3. RESULTS AND DISCUSSION

3.1 Growth of sweet corn as affected by fertilizer applications under no tillage operation

The mean values of plant height at 20, 40, 60 DAS and ear height in plots treated with different fertilizers are presented and discussed in this section.

3.1.1 Plant height at 20, 40 and 60 DAS

Table 2 shows the mean plant heights of sweet corn measured at 20, 40 and 60 DAS. Based on statistical analysis, it was found out that heights of sweet corn at 20 DAS was not significantly affected by the fertilizers applied under no tillage condition. It was observed that sweet corn plants planted in those plots treated with ½ RRIF + 1 ton Vermicompost ha^{-1} (T_4) had the tallest heights with an average value of 42.78 cm. It was then followed by sweet corn plants planted in those plots with full RRIF + 1 ton Vermicompost ha^{-1} (T_6) having an average height of 41.25 cm. Shortest plants were noted in plots with no fertilizer application (T_1). However, the report of [12] was that that there is a significant increase in growth parameters including plant height and number of leaves of corn plants when applied with NPK fertilizers.

At 40 DAS, no significant effects were also noted among sweet corn plants treated with different fertilizers under no tillage condition. Tallest plants were observed in experimental plots with T_2 were full recommended rate of inorganic fertilizer was applied having an average height of 129.85 cm. Plants with no fertilizer application remains to be the shortest at 40 DAS. This result was

opposite to the findings of [13] that corn plants when treated with fertilizers would cause significant increase in its height, stem diameter and other growth parameters.

Table 2. Plant height at 20, 40, 60 DAS and ear height of sweet corn as affected by fertilizer application under no tillage operation

TREATMENTS		Plant Height, cm			Ear Height, cm
CODE	DESCRIPTION	20 DAS	40 DAS	60 DAS	
T_1	No fertilizer	38.43	115.05	185.70	86.20
T_2	Full RRIF	41.20	129.85	189.97	85.53
T_3	2 tons Vermicompost ha^{-1}	36.93	122.83	198.70	89.20
T_4	½ RRIF + 1 ton Vermicompost ha^{-1}	42.78	123.37	177.93	81.50
T_5	½ RRIF + 2 tons Vermicompost ha^{-1}	39.15	119.85	184.70	83.47
T_6	Full RRIF + 1 ton Vermicompost ha^{-1}	41.25	125.37	193.47	90.50

At 60 DAS, no significant difference was noted among plants treated with different fertilizer materials under no tillage condition, however, this result is contradictory to the report of [14] that application of fertilizer particularly nitrogen could cause increase in height of corn as it will promote more cell division leading to an enhanced vegetative stage.

3.1.2 Ear height of sweet corn

As reflected in Table 2, the ear height of sweet corn plants were not significantly affected by the imposed treatments. Tallest ear height was manifested by sweet corn plants planted in plots with full RRIF + 1 ton Vermicompost ha^{-1} (T_6) with an average height of 90.50. Statistical analysis declares no significant effect was done by the treatments. This result was in agreement with the result of [15] who reported no significant difference in ear height of sweet corn plants treated with different fertilizer materials. This insignificant difference is attributed to the natural fertility of the experimental area, initial analysis revealed that the area has marginal amount of organic matter which serves as the source of native nutrients in the soil by the growing plants [16].

3.2 Yield components and yield of sweet corn as affected by fertilizer application under no tillage operation

The mean values of ear diameter, ear length and yield (number of ears per hectare) in plots treated with different fertilizer materials under no tillage condition are presented and discussed in this section.

3.2.1 Ear diameter and ear length of sweet corn

The ear diameter of sweet corn is presented in Table 3. Fertilizer treatments gave significant effects towards the ear diameter of sweet corn. Largest ear diameter was observed in those plots applied with full RRIF + 1 ton Vermicompost ha^{-1} (T_6) with an average diameter value of 4.97 cm while smallest ear diameter was observed in plots with no fertilizer application with an average value of 4.13 cm. Comparison of means revealed that the application of full RRIF + 1 ton Vermicompost ha^{-1} has no significant difference with that of T_2, T_4 and T_5 but significantly different with treatment 1 and treatment 3. These results confirmed the findings of [17] who reported that application of amendments like fertilizer with NPK can lead into an increase in plant height, stem girth, number of leaves, leaf area, number of cobs, ear diameter and length, weight of cob, 100-grain weight, and grain yield of maize.

Moreover, the ear length of sweet corn gave also a significant response on the influence of fertilizers applied under no tillage condition (Table 3). Ear length of sweet corn plants planted in plots treated with full RRIF + 1 ton Vermicompost ha^{-1} (T_6) gave a significant long ear length with a value of 21.57 cm. However, post hoc test reveals that the no significant difference in ear length was observed between T_6 and T_2 (full RRIF). Furthermore, T_6 was significantly longer in ear length than those with T_1, T_3, T_4 and T_5. Results agree to the reports of [12,13,14,17] who reported that application of fertilizers particularly with inorganic fertilizers could cause proliferation and increase in corn growth and yield performance as it will supply the nutrients needed by the planted crop in its available form, thus further process like mineralization is no longer needed, hence, there is an ease of nutrient absorption by the growing crops.

3.2.2 Yield (number of ears) of sweet corn per hectare

The yield of sweet corn as affected by fertilizer application planted under no tillage operation is presented in Table 3. Results have revealed that sweet corn plants planted in plots treated with full RRIF + 1 ton Vermicompost ha^{-1} (T_6) gave the highest number of ear yield of 49369 per hectare. Lowest yield was observed in those plots with no fertilizer application with a value of 44373 ears per hectare. Analysis of variance among the yield data gathered revealed that the fertilizer materials significantly influence the yield parameter of sweet corn. Post hoc test further revealed that sweet corn plants planted in plots with full RRIF + 1 ton Vermicompost ha^{-1} was significantly the highest in terms of yield, which confirms the results reported by [12,18] that fertilizer materials are capable of increasing the yield of corn as these materials can supply the needed nutrients by the plants that it may proceed with further metabolism and in producing ears. The combined effects of inorganic and organic fertilizer had caused the great increase in yield as application of full RRIF alone gave only a yield of 47634 per hectare which was significantly lower than T_6 [13,14,17]. Plots with no fertilizer application (T_1) gave a yield that was not significantly different with T_3, T_4 and T_5. The experimental area has a marginal amount of organic matter [20] making sweet corn plants still very productive amidst no application of fertilizer in T_1. On the other hand, as reported by [18,19], in order to maximize yield, the application of fertilizer particularly N fertilizer may cause an increase in yield.

Table 3. Ear diameter, ear length and yield of sweet corn as affected by fertilizer application under no tillage operation

TREATMENTS		Ear † diameter, cm	Ear length†, cm	Yield † (number of ears) ha^{-1}
CODE	DESCRIPTION			
T_1	No fertilizer	4.13 c	17.57 d	44373 c
T_2	Full RRIF	4.87 ab	20.13 ab	47634 b
T_3	2 tons Vermicompost ha^{-1}	4.57 b	19.37 bc	44917 c
T_4	½ RRIF + 1 ton Vermicompost ha^{-1}	4.60 ab	19.10 bcd	44600 c
T_5	½ RRIF + 2 tons Vermicompost ha^{-1}	4.63 ab	18.20 cd	45280 c
T_6	Full RRIF + 1 ton Vermicompost ha^{-1}	4.97 a	21.57 a	49369 a

† Means followed by the same letter(s) are not significantly different at 5% level of significance based on HSD

3.3 Soil chemical properties at harvest as affected by fertilizer application under no tillage operation

The mean values of soil pH, organic matter content (%), extractable P (mg ka^{-1}) and exchangeable K (cmol kg^{-1}) in plots treated with different fertilizers are presented and discussed in this section.

3.3.1 Soil chemical properties at harvest

The pH was significantly affected by the imposed fertilizer treatment based on soil analysis conducted [21] after harvest as presented in Table 4. Plots with no fertilizer application (T_1) had the highest pH value of 5.85 which was significantly higher with those plots treated with Full RRIF + 1 ton Vermicompost ha^{-1} (T_6). However, post hoc analysis using HSD at 5% level of significance revealed that T_1 pH value has no significant difference with of T_2, T_3, T_4 and T_5. Results presented by [22] is opposite to the findings of the study. The reason is due to the short period of time that sweet corn plants stay in the field. Sweet corn plants are harvested in less than 3 months which would cause incomplete reactions with the soil. Leading to a minute change in pH.

Organic matter content of the soil was found significantly affected by the imposed treatments based on statistical analysis. Highest organic matter content was observed in plots applied with ½ RRIF + 2 tons Vermicompost ha^{-1} (T_5) followed by those plots treated with 2 tons Vermicompost ha^{-1} (T_3), ½ RRIF + 1 ton Vermicompost ha^{-1} (T_4), Full RRIF + 1 ton Vermicompost ha^{-1} (T_6) and lastly T_1 (no fertilizer) and T_2 (Full RRIF). Post hoc test reveals that T_5 value was not significantly different with that of T_3, T_4 and T_6.

But significantly higher with that of T_1 and T_2. Application of organic fertilizer like Vermicompost can readily increase and improve the amount of organic matter in the soil as reported by [15,16]. The extractable P measured in mg kg^{-1} was not significantly affected by fertilizer treatments. However, highest value was obtained by those plots applied with ½ RRIF + 2 tons Vermicompost ha^{-1} (T_5). Exchangeable K was also not significantly affected by the imposed treatments of fertilizer. Highest value was also obtained by those plots treated with ½ RRIF + 2 tons Vermicompost ha^{-1} (T_5). Treatment 5 got the highest values for extractable P and exchangeable K at harvest.

Table 4. pH, organic matter content, extractable P and exchangeable K of soil at harvest as affected by fertilizer application

TREATMENTS		Some Soil Chemical Properties at Harvest			
CODE	DESCRIPTION	pH †	Organic Matter † Content, %	Extractable P, mg kg^{-1}	Exchangeable K, cmol kg^{-1}
T_1	No fertilizer	5.85 a	3.93 b	11.00	1.24
T_2	Full RRIF	5.59 ab	3.93 b	14.33	1.20
T_3	2 tons Vermicompost ha^{-1}	5.84 a	4.11 ab	14.17	1.21
T_4	½ RRIF + 1 ton Vermicompost ha^{-1}	5.72 ab	4.05 ab	10.17	1.13
T_5	½ RRIF + 2 tons Vermicompost ha^{-1}	5.65 ab	4.15 a	16.33	1.26
T_6	Full RRIF + 1 ton Vermicompost ha^{-1}	5.54 b	4.00 ab	13.33	1.23

†Means followed by the same letter(s) are not significantly different at 5% level of significance based on HSD

4. CONCLUSION

Favorable response of sweet corn applied with different fertilizer materials were observed in the study. No significant influence was noted among the growth parameters (plant height at 20, 40, 60 and ear height) of sweet corn treated with different fertilizer materials, however, significant differences among treatments were realized on the ear diameter, ear length and number of ears per hectare. The application of full recommended rate of inorganic fertilizer plus 1 ton vermicompost ha^{-1} gave the highest yield of sweet corn under no tillage operation of Bukidnon soil. These findings also conforms to the reports of other researchers. Hence, Bukidnon condition under no tillage operation would provide significant sweet corn yield with the application of inorganic fertilizer combined with organic fertilizer. Moreover, post soil analysis revealed that there will be an increase in organic matter content of the soil whenever organic fertilizers are used, as this was known to have direct effect and benefit towards the soil's chemical property particularly on the organic matter content. Thus, the increase in organic matter would signify preservation and improvements of some soil properties like porosity, structure, bulk density, water holding capacity and others. The combination of inorganic and organic fertilizer caused significant effects towards the yield of sweet corn and soil properties, thus, highly recommended in a no tillage operation under Bukidnon condition.

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